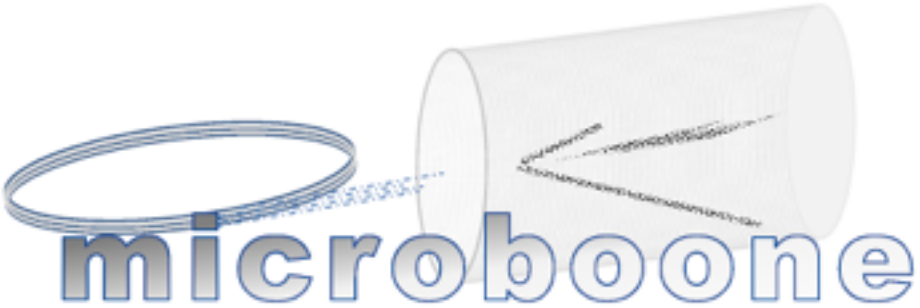


MicroBooNE DAQ

Eric Church, FNAL/PNNL

DAQ/Online Computing

23-Feb-2015

Outline

- MicroBooNE DAQ System Overview
- System Components
- Data flow

Overview of DAQ Project

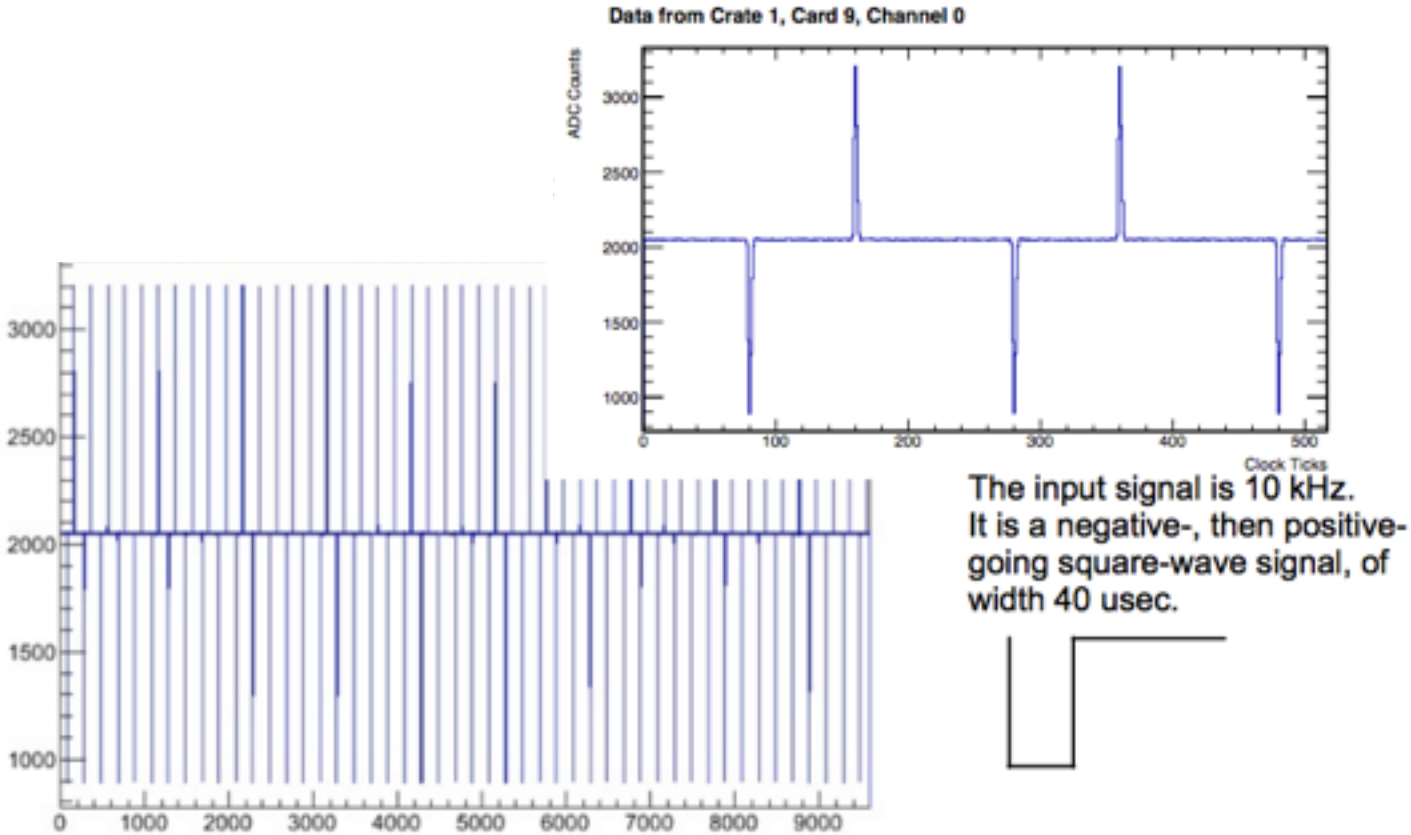
- The MicroBooNE DAQ is responsible for reading out, assembling events, writing them to file.
- But also:
  - Monitoring and Control: EPICS database
  - Beam data concatenation
  - Online monitoring
  - Run Control
    - Calibration runs, Laser Runs, Regular runs ...
  - Swizzling (DAQ binary to ART ROOT format)
  - DAQ DBs and interaction with Offline dB
  - Data management (PUBS), ...

MicroBooNE Status

- CD3b March, 2012.
- CD4 December, 2014
- Electronics Reception Tests have been run all the while, using much of the full DAQ and its moving parts.
  - Through 2013 and 2014 as the TPC was constructed, sealed up in the cryostat and moved to LArTF
  - Collected PMT data in 2014 when that system was installed into the cryostat

Calibration vertical slice tests

- We ran periodic vertical slice tests over the past 2 years to test electronics, pre cryostat, after cryostat, and after move to LArTF



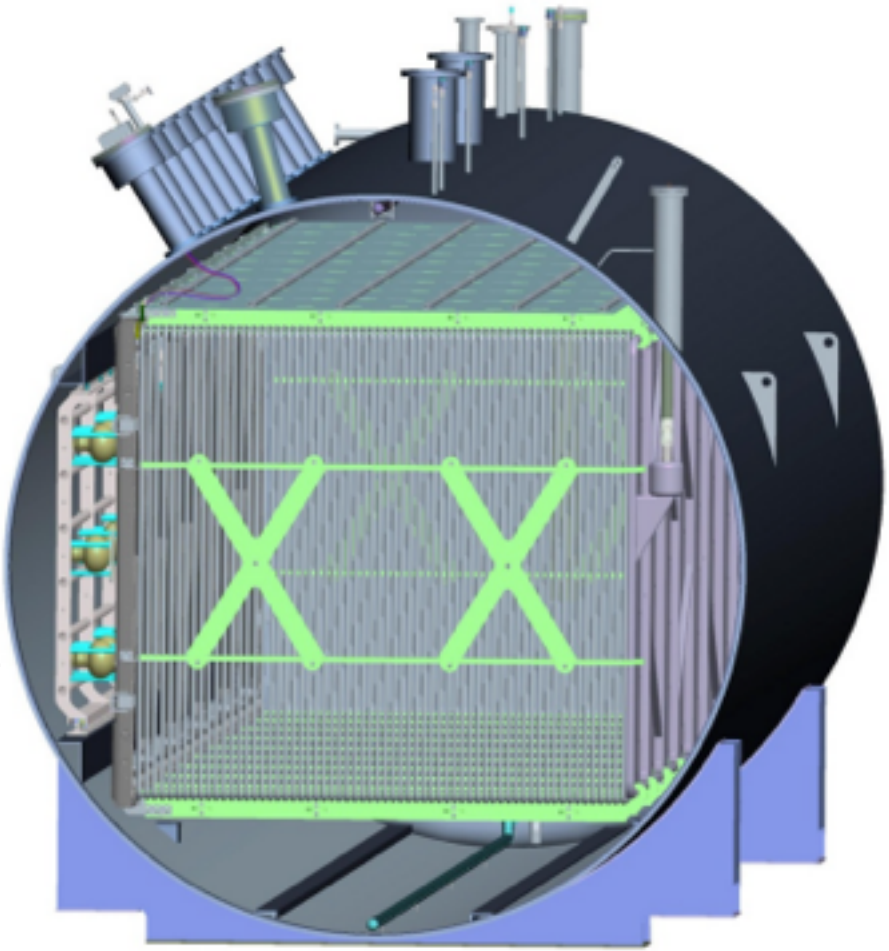
MicroBooNE DAQ now

- DAQ is installed, connected, running at LArTF (MicroBooNE enclosure)
  - Computers up and running; racks, electronics all connected, platform over cryostat in place.

- The MicroBooNE DAQ team is comprised of the following institutions :
  - Yale, LANL, FNAL, PNNL, Nevis/Columbia, KSU, Otterbein
    - Manchester, Oxford, others pitching in on RunControl …

MicroBooNE instrumentation

- 8256 wire channels
- 32+4 PMTs

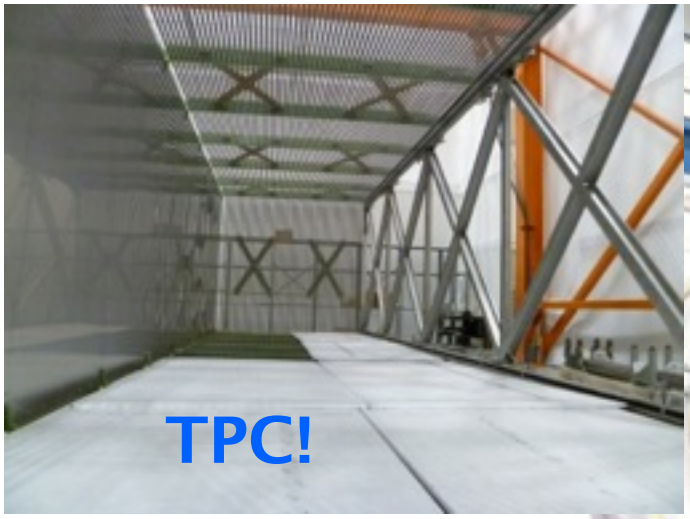


data on Wires are the projections in 3 views. Allows reconstructing back to 3D tracks and showers.

PMT data to trigger, to determine t0 for cosmics subtraction, and perhaps late/early light for pID.

The ship goes by almost instantaneously, and you see the flash from the light on its bow; the waves lap up on shore much later.

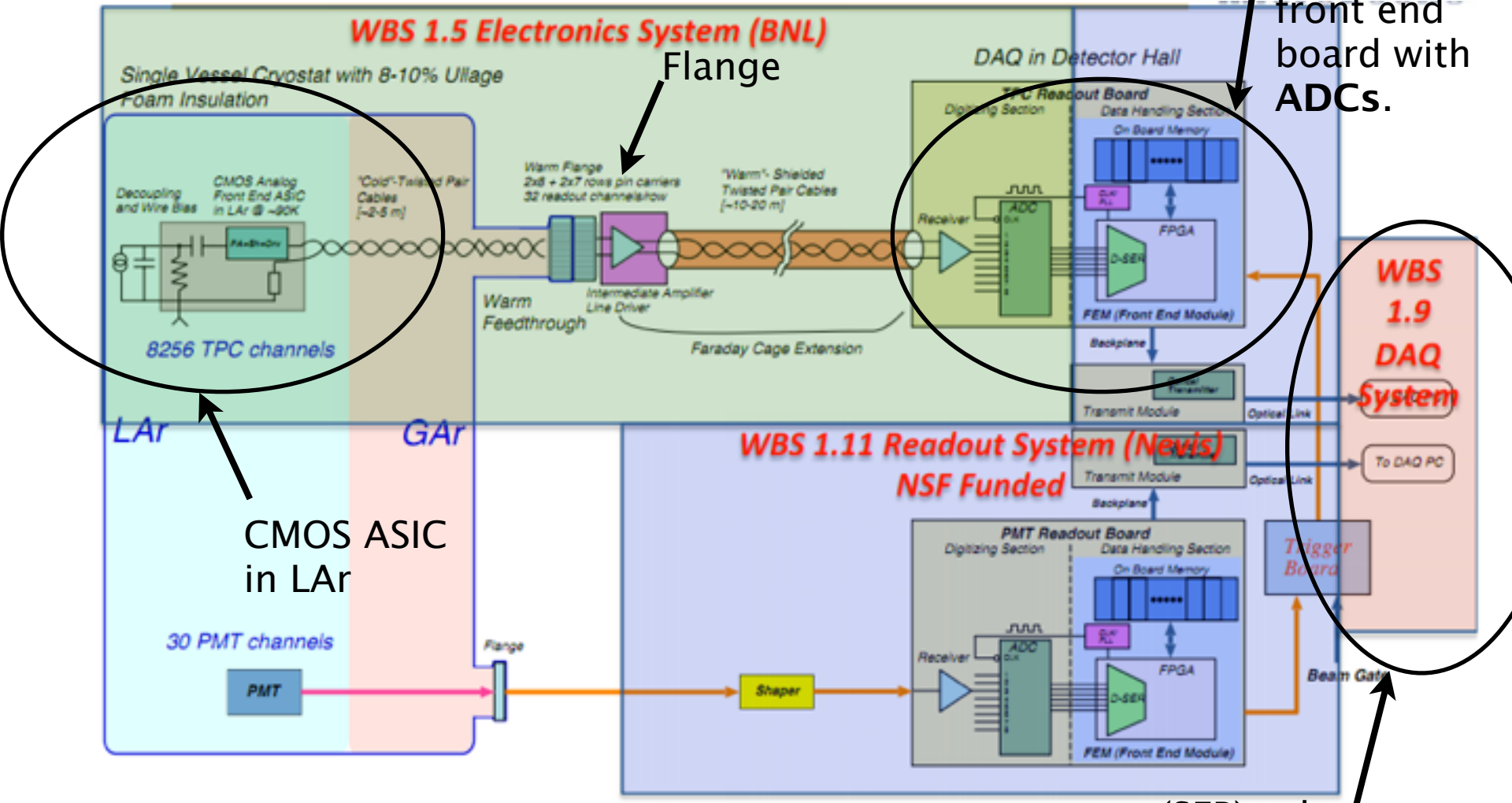
MicroBooNE TPC/Cryostat pictures



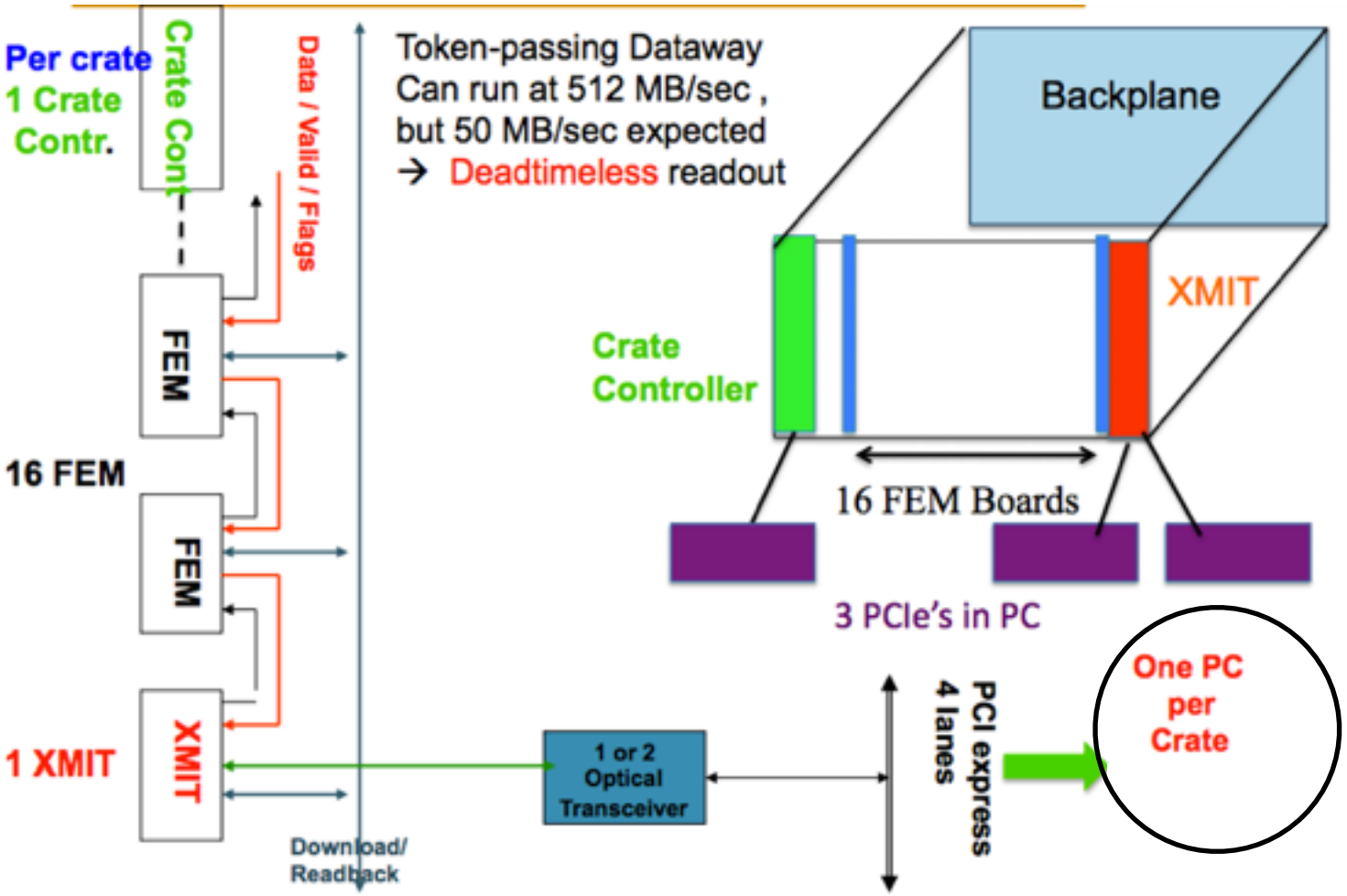
From March, 2013

Out at LArTF now

System Overview

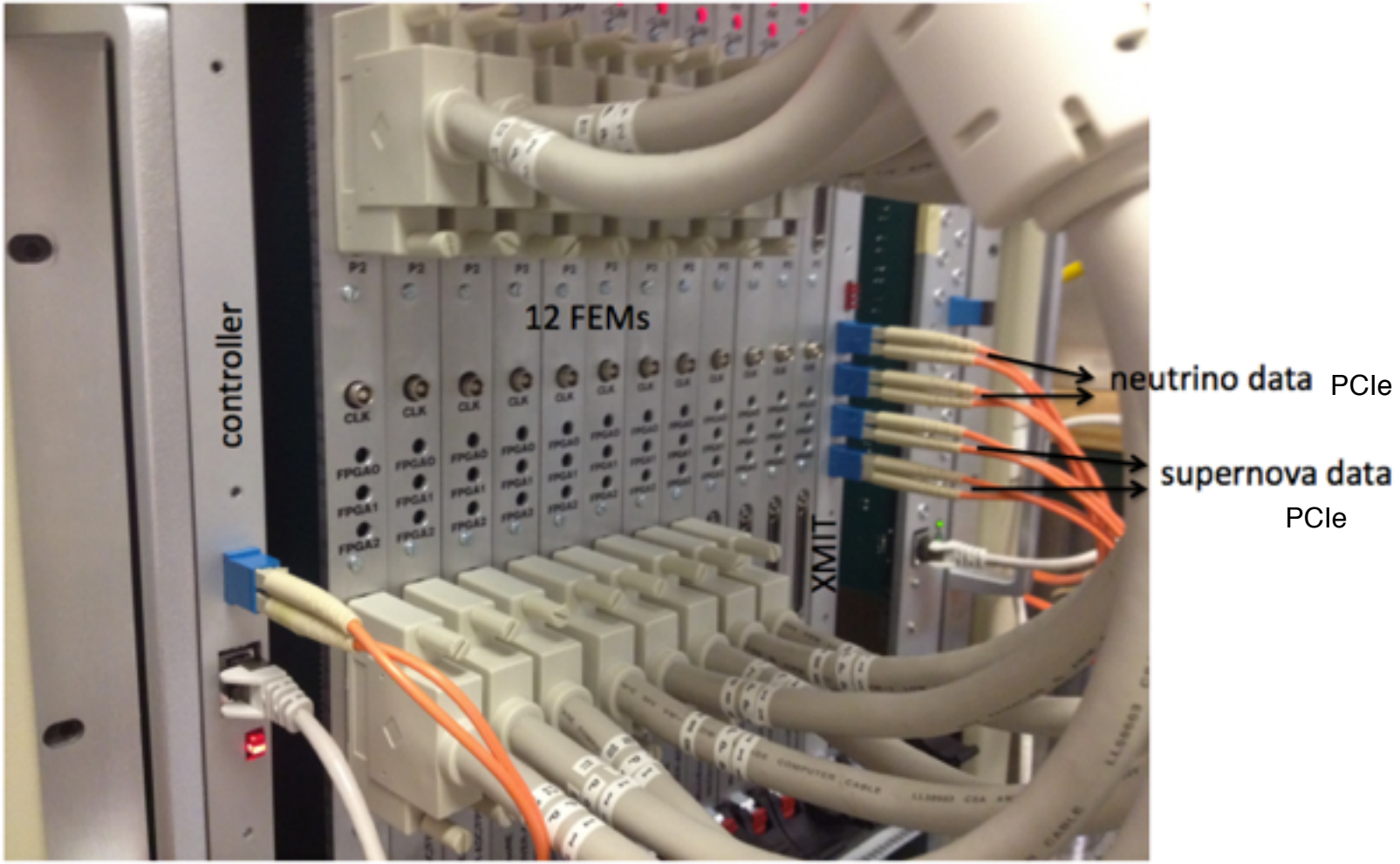


Nevis TPC Crates (x9)



Wires are sampled@2MHz, 2 bytes

Nevis warm electronics

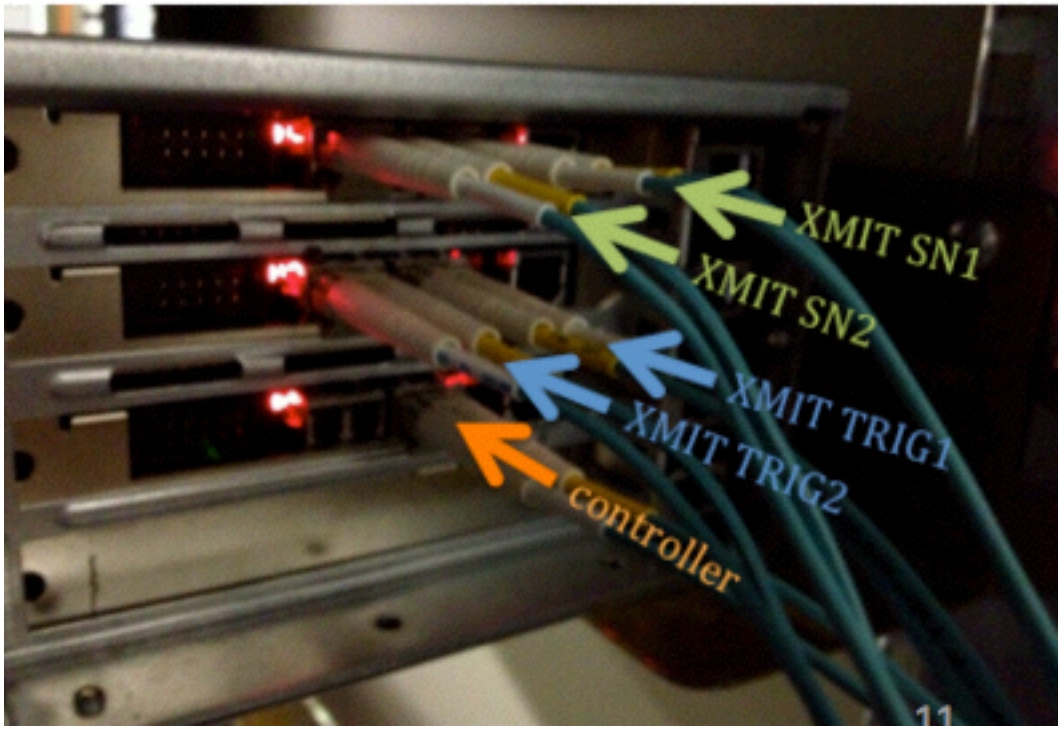


Fibers into SEB-computers

SEB == Sub Event Buffer <==> basically one crate.

There are two data streams.
(1) Triggered
(2) Supernova:
continuous stream

Both come through the "XMIT" card on duplex fibres.



Three NEVIS custom PCIe cards per SEB.

2 data streams

- Beam physics: triggered stream
  - confirm/refute/dispute miniBooNE BNB sub-500 MeV excess
  - x-sections in Argon
  - But also: NuMI events
  - Charge calibrations; Laser calibrations
  - “Strobe” events
- non-Beam physics: Supernova stream
  - Every single 1.6 msec frame, one after the other
  - Will fill seven 2 TB disks in two days on each crate.
  - GPS time of event will allow to dig through and recover 1-2 hrs around the candidate SN, as reported from SNEWS
  - non-trivial disk-read, network-heavy task.
    - data moving, reaping always running (PUBS)

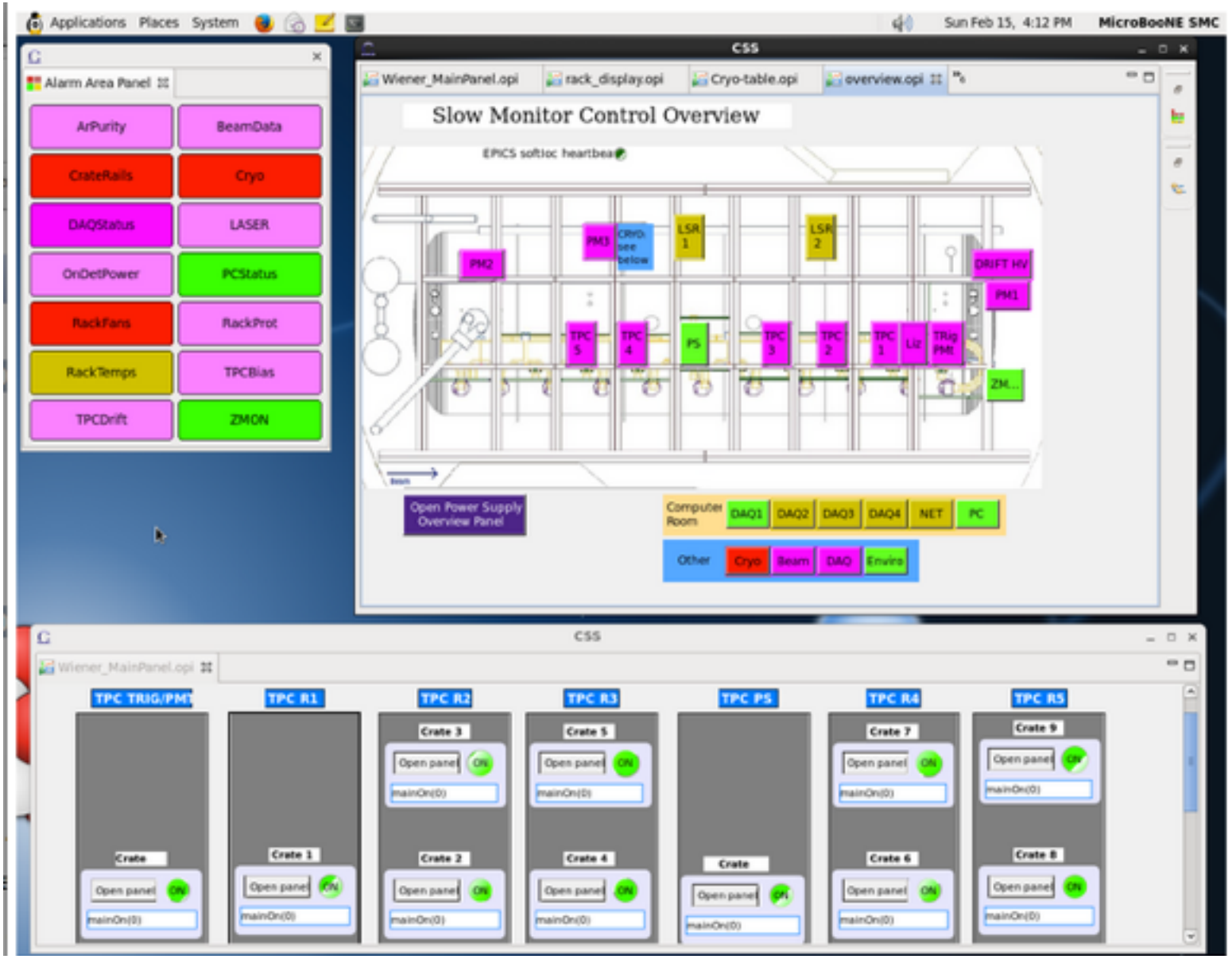
DAQ software support

- SCD SSA team — Kurt Biery's group, mainly Gennadiy — has been instrumental in writing/supporting DAQ software along with Wes/me
  - It's a very scalable, C++ solution, with the assembler and the ~10 "sebApp" processes inside a state machine, communicating via sockets. Shared memory segments for online monitoring – Donatella
  - We have key artdaq components — fragments, event stores — but broke off our needs from that code repository deliberately so as not to be exposed to forced upgrades.
  - Nova's Run Control system

Slow Monitoring and Control

- we run EPICS on our DAQ DB server
- The 9 Wiener power supplies for the TPC warm electronics crates are under password-protected remote control/monitoring
- Similarly, with the ASICs power and drift and bias voltages
- Rack fans, temperatures are monitored by on-rack single board computers (Glomations) and report to EPICs. Cryo monitoring via IFIX to EPICs.
- Computer temperatures, fan speeds, RAID status also reported to EPICs. Gangia metrics also go to EPICs.
- Impedance between Detector/Building reports rii,
- All summarized for shifter and alarmed/archived.

SlowMonCon pictures



uB DAQ Test Stand

- We have a Test Stand at LArTF, as well, with two crates in computer room.
  - One server reads one crate's worth of FEMs for wires (~960 wires)
  - One server reads at least one FEM card in one crate of PMTs
  - A third server is the test stand event builder.
  - All servers are on a separate private network.
  - These crates do not read actual PMTs or wires in the tight space of the computer room
  - Though, if needed we have a test flange (chimney) we can connect to at DAB
- We test kernel upgrades, if needed, here.
- These serve as our hot-swap machines too

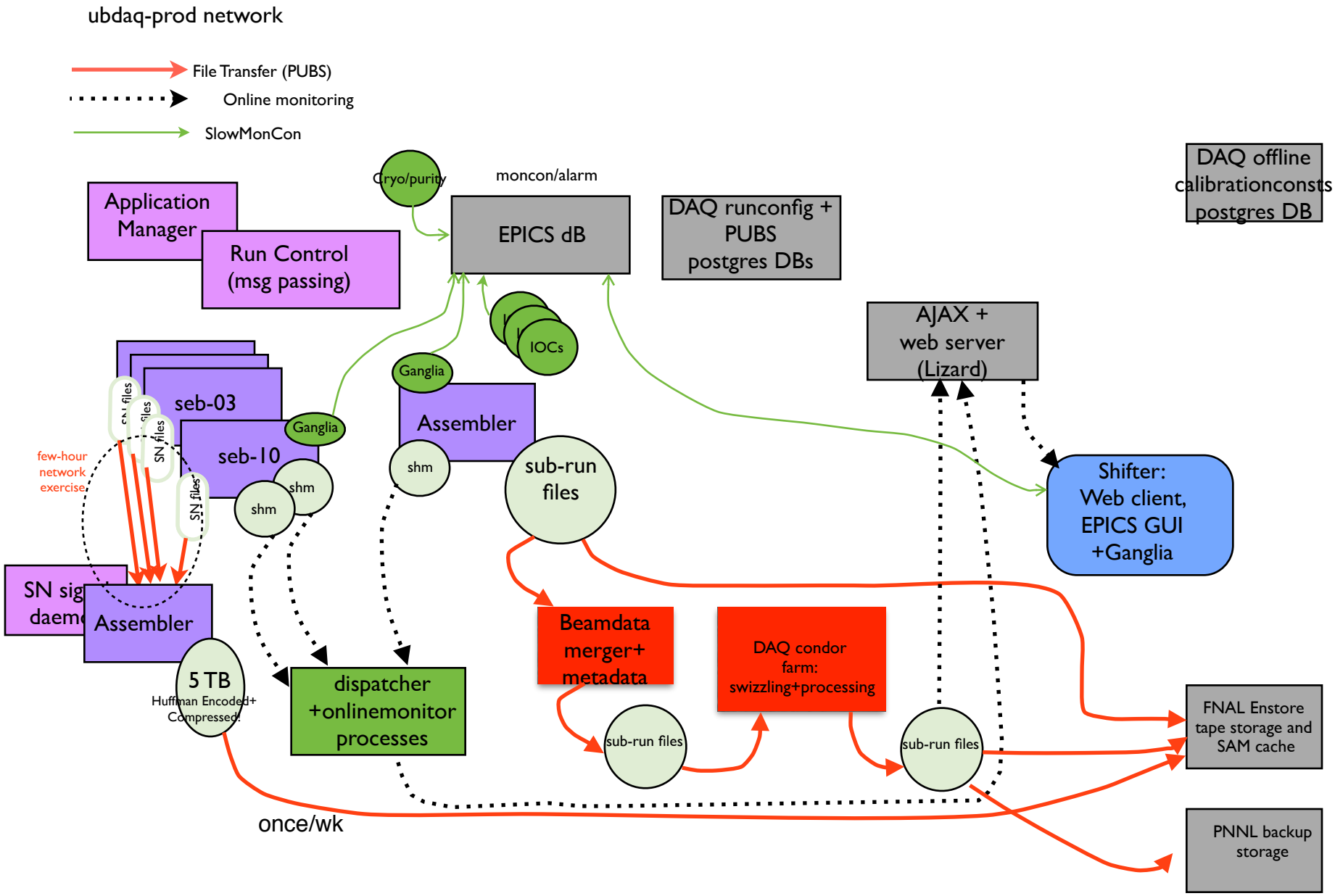
DAQ Servers

Test Stand

Server administration

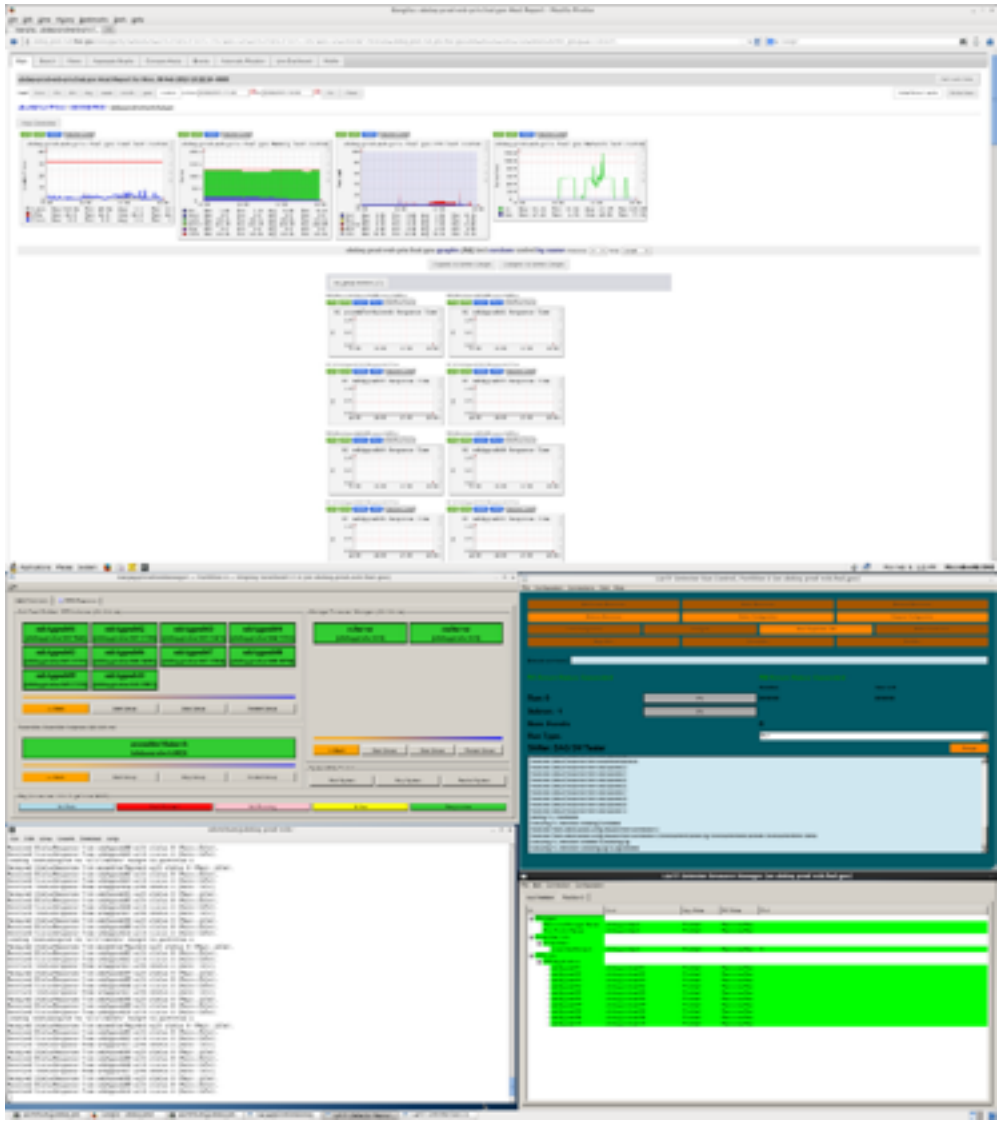
- The SCD-SLAM team — Rennie, Bonnie, Jason, et al. — formally maintain all 15 of our production servers
  - It's been a very smooth and professional arrangement
  - We run SLF6.6
    - perhaps no pressing need to take any of these further, though we may go to 6.7 with its networking bug fix.
    - We have satisfactory root access, as well, as needed for modest scope changes
    - There will soon be ACL rules to only allow access in via 2 gateway nodes
  - When our laser control is at the appropriate stage we will hand them admin duties of these two servers, as well. Perhaps our 4 test stand machines too.

Online DAQ systems



In ROCW…

Ganglia



Run Control
(appropriated from NOvA)

Current work

- We are now plugging in our runConfig DB, from which to make our fcl files, and ensure legitimate detector configurations.
- PUBS data flow details being finished
- Need Huffman encoding running working
- Need to add the trigger fragment to the event
- Port to a new uboonedaq_datatypes and code changes to accommodate it.

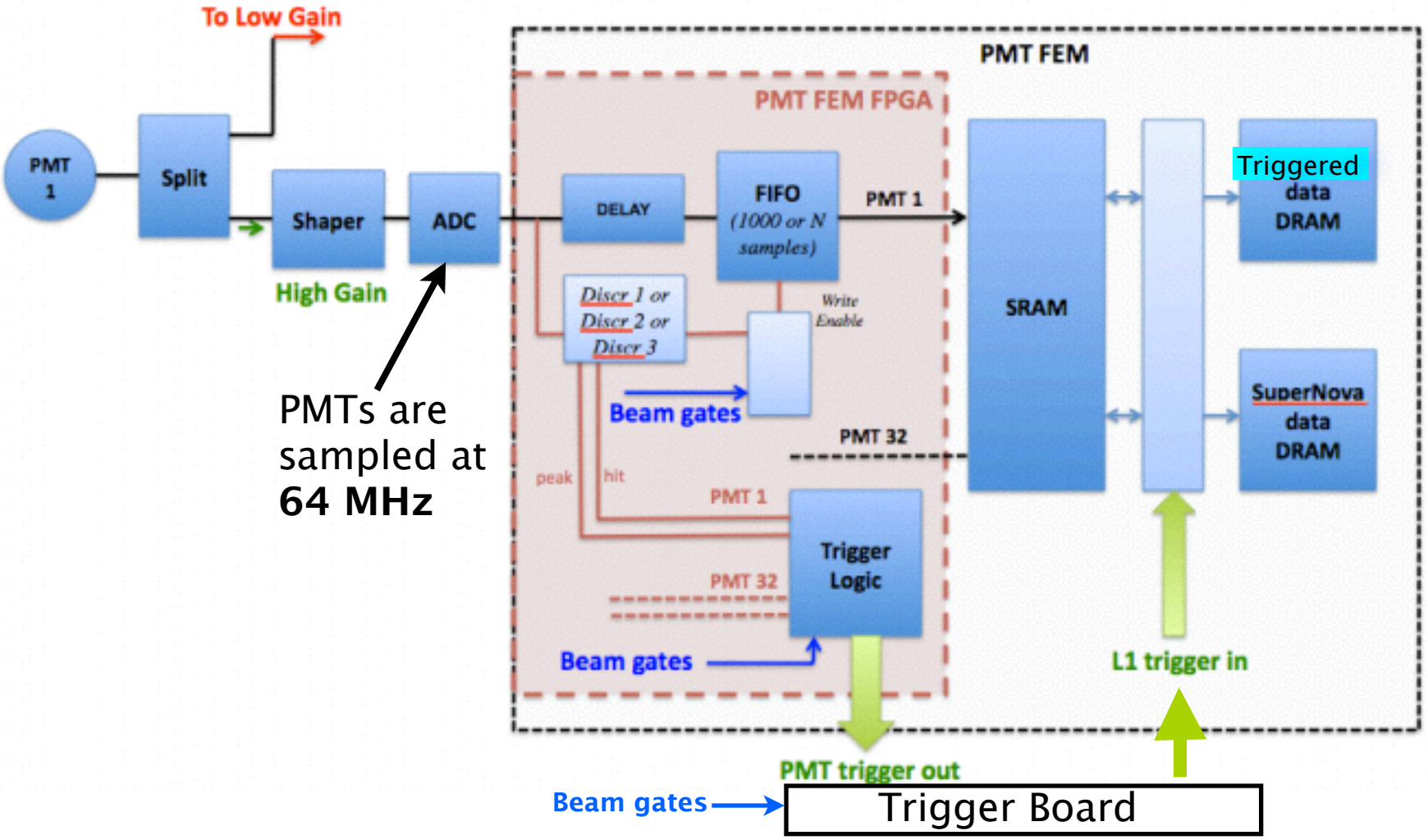
- SN mode

Summary

- All the DAQ moving parts are accounted for and in mature development or are complete.
- Good instructions and list of tasks at https://cdcvs.fnal.gov/redmine/projects/uboonedaq/wiki
- Exciting times for MicroBooNE!

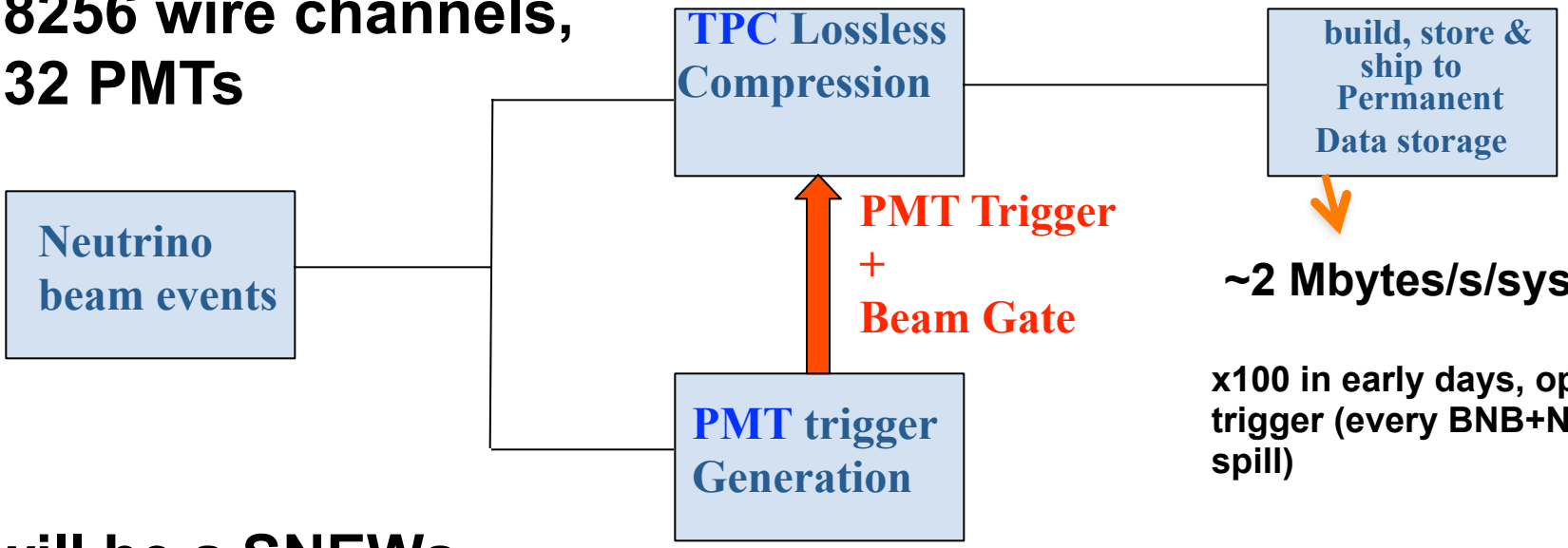
Backup Slides

Trigger


To Low Gain
PMT 1
Split
Shaper
ADC
High Gain
PMTs are sampled at 64 MHz
PMT FEM
PMT FEM FPGA
DELAY
FIFO (1000 or N samples)
PMT 1
Discr 1 or Discr 2 or Discr 3
Write Enable
Beam gates
PMT 32
peak
hit
PMT 1
PMT 32
Trigger Logic
Beam gates
SRAM
Triggered data DRAM
SuperNova data DRAM
L1 trigger in
PMT trigger out
Beam gates
Trigger Board

Digitizing Boards: MicroBooNE design

8256 wire channels, 32 PMTs

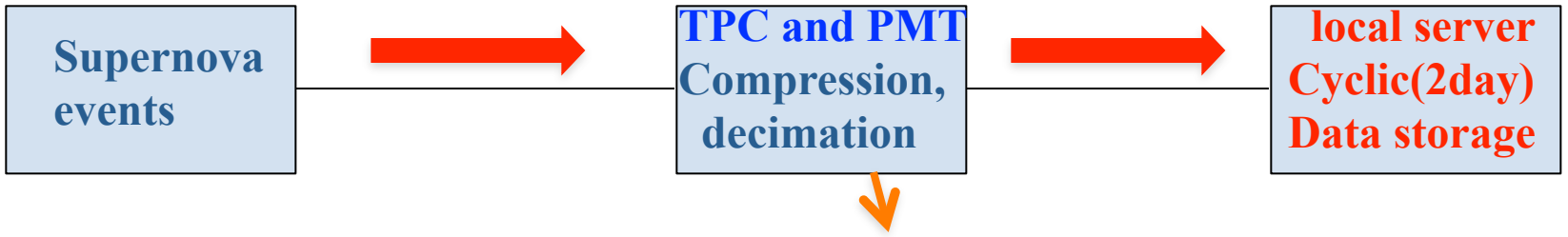


~2 Mbytes/s/system

x100 in early days, open trigger (every BNB+NuMI spill)

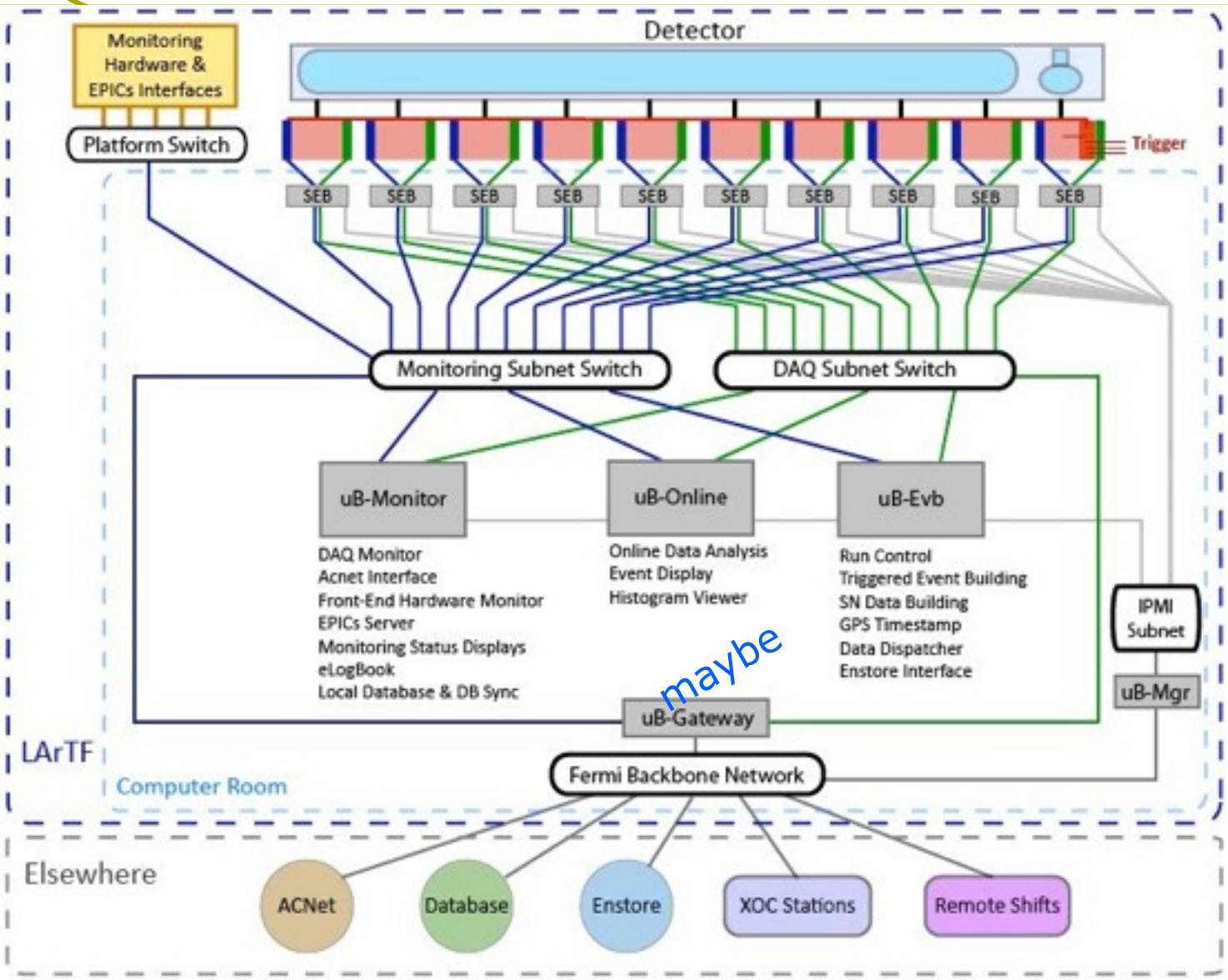
We will be a SNEWs *consumer*.

Continuous TPC and PMT readout

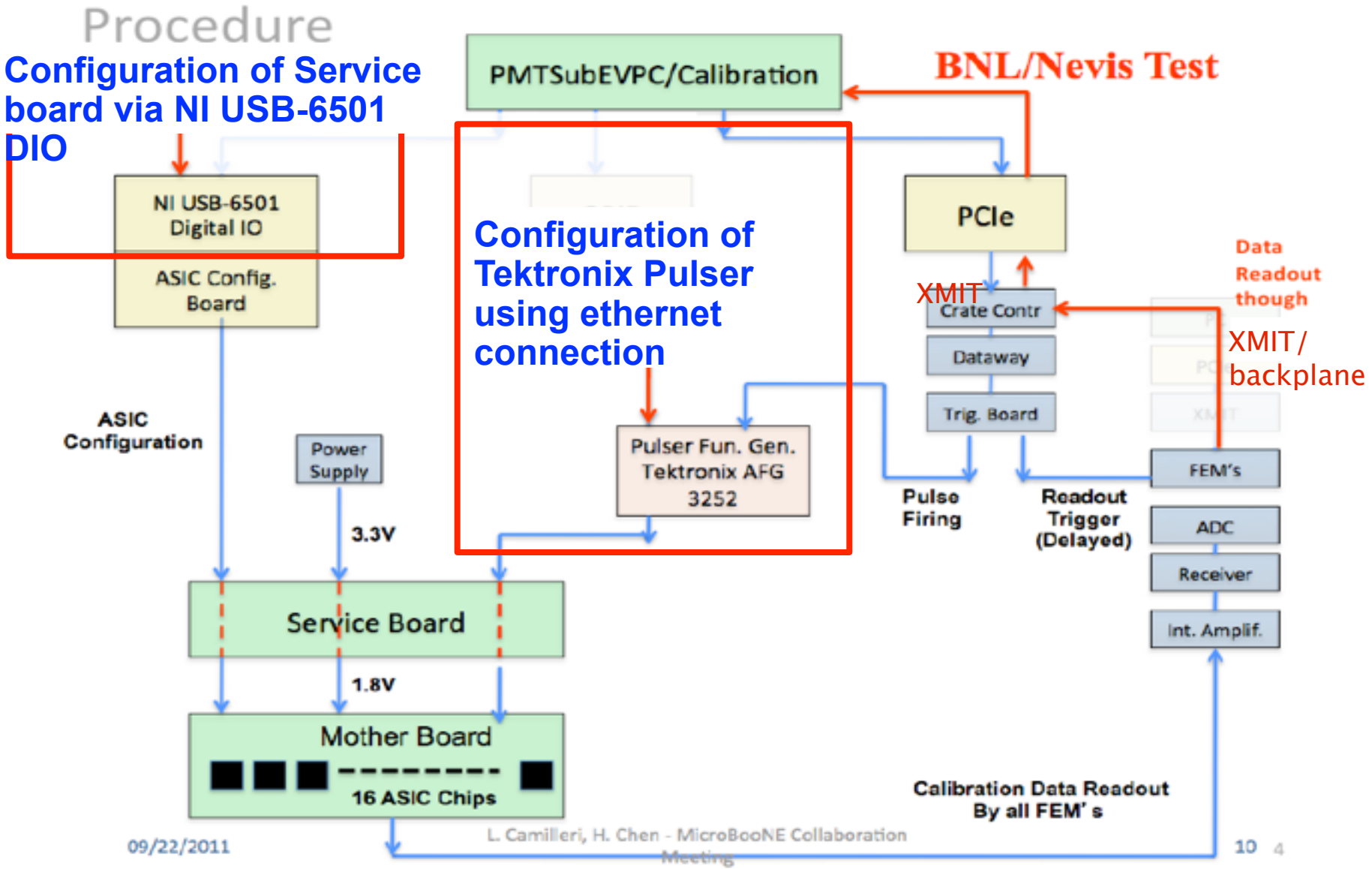


100 Mbytes/s/crate (7 TB/day)

DAQ Network/Process Overview

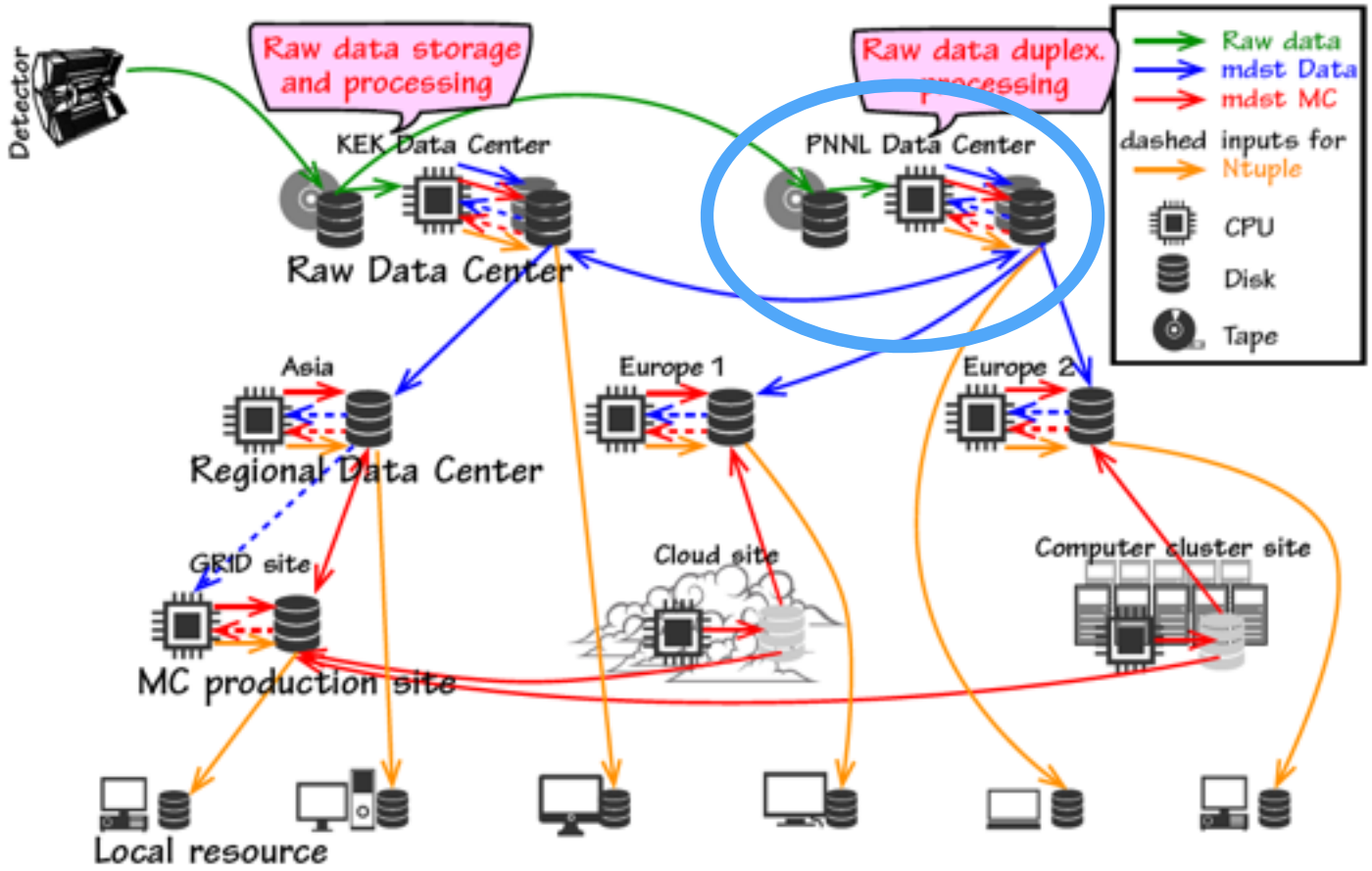


Calibration Hardware



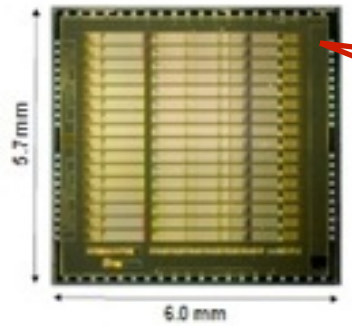
PNNL as second data site

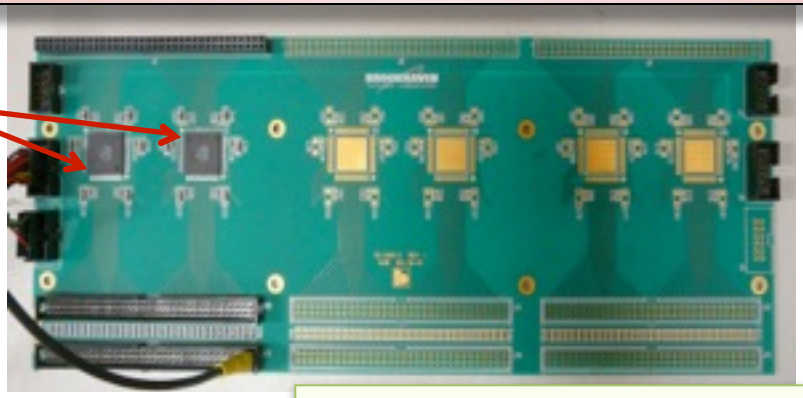
- Will do this for Belle II's 200 PetaBytes



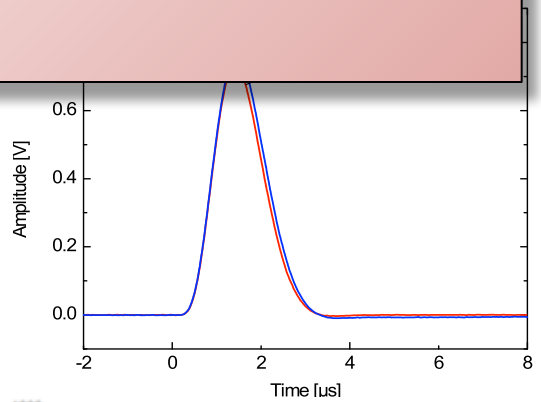
Cold CMOS Analog Front End ASIC & Motherboard

ASIC die & package

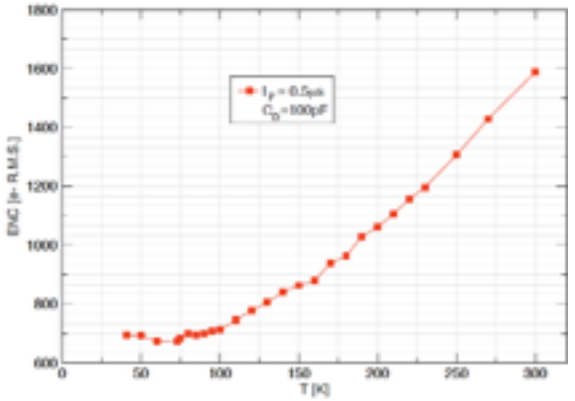




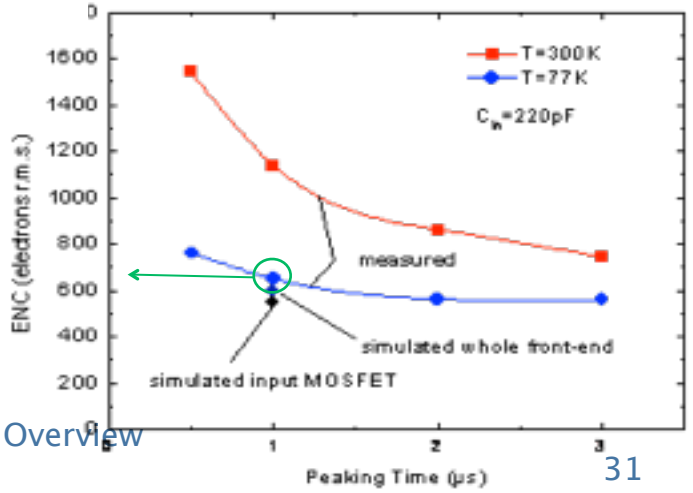
Cold motherboard with 12 ASICs chips (2 shown)



- 16 channels per chip
- Charge amplifier, high-order filter
- Adjustable gain: 4.7, 7.8, 14, 25 mV/fC (55, 100, 180, 300 fC)
- Adjustable filter time constant (peaking time): 0.5, 1, 2, 3 μs
- Selectable dc/ac (100 μs) coupling
- 136 registers with digital interface
- 5.5 mW/channel (input MOSFET 3.6 mW)
- Designed for long cryo-lifetime

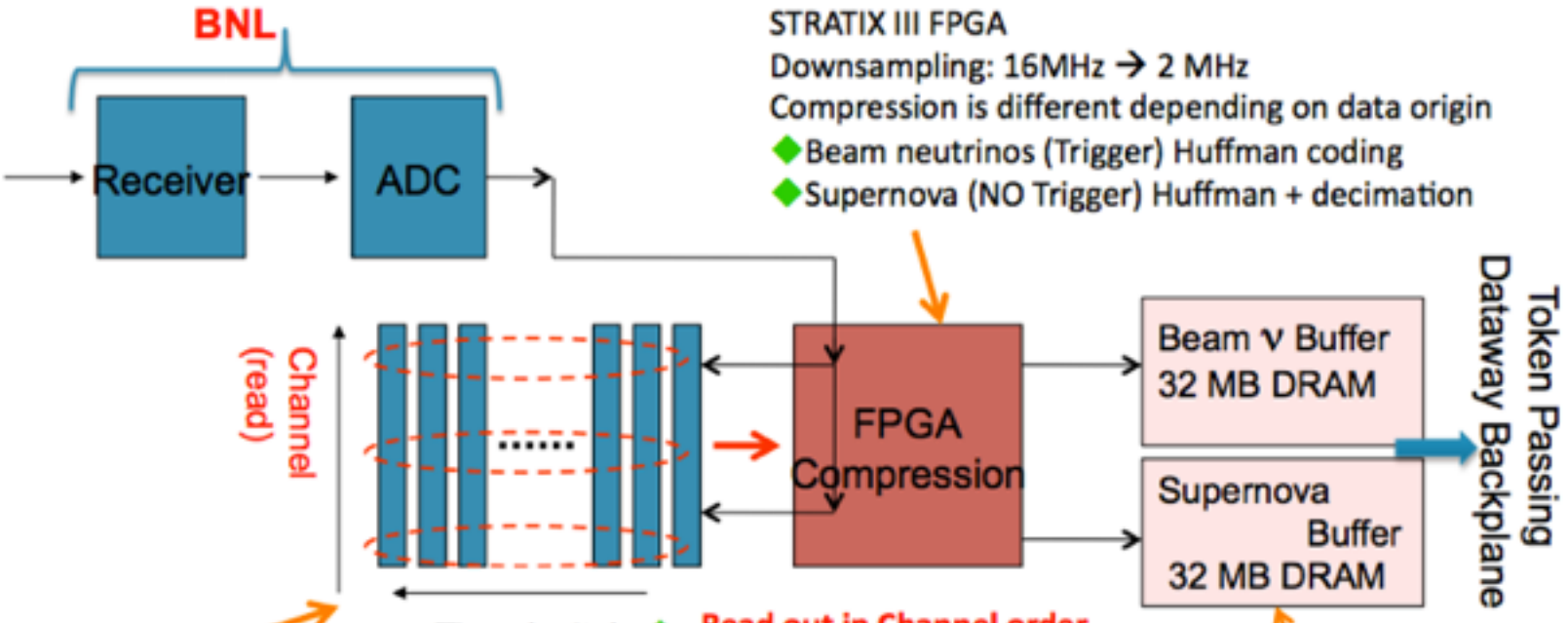


- Circuit performance is almost identical at 300K and 77K, except noise is ~2x lower
- Calibration capacitor on ASIC changes by ~0.5% from 300K to 77K
- **Cycle #4* chips: Passed all tests**



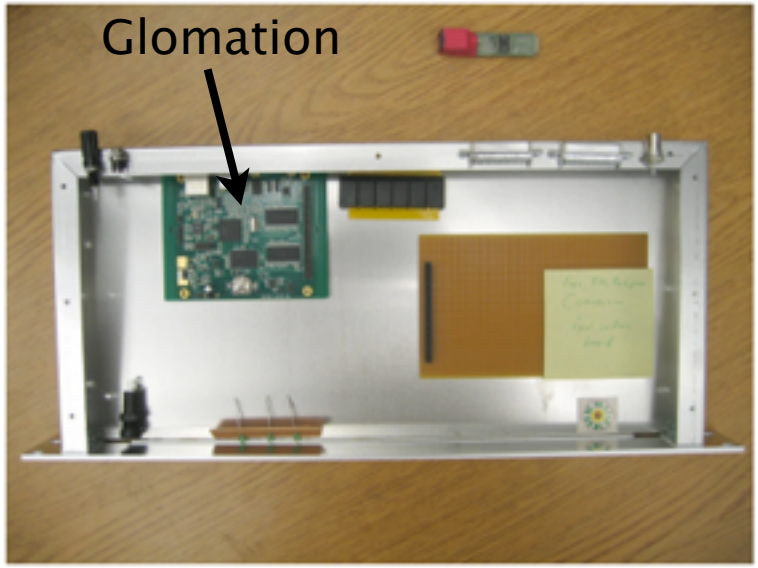
Overview: Digitizing Boards: Hardware and Tasks

Continuous Data rate per card: 64 wires x 2 MHz = 128 MHz 12 bit ADC words.



Glomation Single Board Computer GESBC-9G20

- SBC includes
  - Linux OS
  - Ethernet
  - RS232
  - USB
  - 40 digital I/O
  - 4 ADC
  - I2C and SPI bus



- Interfaces directly with
  - **Glassman Drift HV – RS232**
  - **Rack Temperature – I2C bus using Maxim DS1624**
  - **Rack Fanpack – digital I/O**

Glenn Horton-Smith, KSU